CROPLAND EROSION

prepared by
U.S. Department of Agriculture
Soil Conservation Service

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Water Resources Council's
Second National Water Assessment

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FOREWORD

The Water Resources Planning Act of 1965 (Public Law 89-80) provides for the Water Resources Council to maintain a continuing study of the adequacy of the Nation's water resources to meet present and future water requirements. In 1968, the Council reported the results of its initial assessment activities.

The 1968 report put into nationwide perspective, estimates of present and future water and related land requirements and supplies for 20 water resource regions. It also presented the opinions of water professionals nationwide concerning the Nation's severe existing and emerging water resource problems.

The Water Resources Council is now conducting activities leading towards its second major assessment report which is scheduled for publication early in 1978. This assessment has 1975 as the base year for analysis with projections being made for 1985 and 2000.

Activities leading toward the publication of the 1975 National Water Assessment are divided into three major phases: Phase One--Nationwide Analysis; Phase Two--Specific Problem Analysis; Phase Three--National Problems Analysis.

The Nationwide Analysis is conducted by the Council's member agencies and reflects the Federal viewpoint about existing and future requirements, the character of the problems and conflicts associated with meeting these requirements, and possible implications for the future.

This report is a product of the Nationwide Analysis and provides a perspective of estimated soil losses from sheet and rill erosion from water on cropland in the 48 contiguous United States for the year of 1975, and projections for 1985 and 2000.

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SUMMARY

This report is an analysis of estimates and projections of soil losses by sheet and rill water erosion on cropland in the 48 contiguous United States for 1975, and projections for 1985 and 2000. Soil losses are related to the production of food and fiber and the effects on water quality. Considerations in the study include conservation treatment on cropland, land use adjustments, the land base for cropland, land development, and economics. Acreages planted to crops range from about 335 million acres in 1975 to 360 million acres projected for 2000.

The methods used for estimating probable soil loss and conservation treatment on cropland for the current and future time periods required certain assumptions, data sources, and procedures. For the 1985 and 2000 projections, a linear programming model developed by the Center for Agricultural and Rural Development, Iowa State University, was used. Data produced on the use and treatment of lands was used in the model to produce estimates of sheet and rill erosion from water. An analysis was made of erosion and other pertinent data by the U.S. Department of Agriculture and other agencies as members of the Agricultural Resources Assessment Committee. This Committee was established to provide the agricultural elements of the Assessment.

The Modified Central Case was developed to display the most likely future and includes projections for 1985 and 2000. It also describes the consequences and effects of this future condition. Nine alternative future conditions were considered in the development of the Modified Central Case.

Over half of the land used for crops in 1975 was subject to sheet and rill erosion with a susceptibility ranging from moderate to very severe. In 1975, soil losses on cropland amounted to almost 3 billion tons or an average of about 9 tons per acre. If no conservation practices had been applied to cropland, soil losses would be a third higher or 4 billion tons. The national soil loss should not exceed about 1.5 billion tons per year for sustained crop production. The study shows that the 1975 estimated loss is nearly twice this amount. Soil losses in most of the Water Resource Regions in the eastern two-thirds of the U.S. exceed tolerable limits, and constitute a serious problem since a large percent of the cropland is in these regions.

When the upper soil layers are eroded away, crop production is substantially reduced. Effectiveness of fertilizers, high producing varieties and good crop management may diminish, and increased amounts of expensive inputs have to be used to maintain production.

The concern for clean water requires that pollutants to ground and surface waters be minimized. Most pollutants from agriculture are classed as "nonpoint" source pollutants. If the 1985 and 2000 projected control

measures are not realized, these "nonpoint" pollutants in the form of sediment, plant nutrients, pesticides, and heavy metals may cause considerable damage to water quality.

Many inputs are essential to meet the 1985 and 2000 Modified Central Case projections. Landowners and operators, government agencies, environmentalists, and all agribusiness groups must become actively involved. Major improvements are needed in proper land management and the establishment of needed conservation systems on cropland. The extent of changes between 1975 and 2000 is reflected as follows:

1. A reduction of cropland with "no conservation treatment" from almost 141 million acres to about 29 million acres;

2. An increase of terraces with minimum tillage from 1 million acres to 15 million acres;

3. An increase in contour stripcropping with minimum tillage from a million acres to 35 million acres;

4. An increase in contour farming with minimum tillage from less than 2 million acres to almost 42 million acres;

5. A conversion of 4 million acres of croplands with moderate to very severe erosion hazards to land uses that are less susceptible to erosion;

6. A conversion of 10 million acres with slight erosion hazards from other land uses to cropland;

7. Additional agriculture research and field experiments are needed to find better systems of conservation farming or to improve on existing systems; and

8. Pertinent legislation, regulations, incentives, etc., may also be needed.

The conditions in the agriculture sector, as reflected in the Modified Central Case analysis, show that the soil resource base with appropriate conservation treatment is capable of meeting the projected food and fiber demands of the future. Erosion can be reduced to tolerable limits while still meeting food and fiber projected needs in the year 2000. But the application of conservation practices would have to greatly increase.

Many landowners have short-range plans aimed at relatively quick returns rather than at conservation, which most often requires long-range planning and investment. Society should share the cost incurred for public benefit. Public involvement will be necessary in programs such as cost sharing in conservation investments. The erosion reductions are contingent upon landowner and operator participation, public support, and equitable arrangements developed and utilized for their efforts to be compatible.

INTRODUCTION

This report is an analysis of soil loss estimates on harvested cropland in the continental United States and the resulting effects on food and fiber production and water quality. It identifies and describes the locations, extent, and magnitude of soil losses by sheet and rill erosion from water on agricultural cropland in time periods--1975, 1985, and 2000. It does not cover other types of erosion such as wind erosion, gully and channel erosion, shoreline erosion, strip mine erosion, etc. The report does not attempt to translate erosion to sediment yield in quantitative terms.

The Modified Central Case (MCC) is based on assumptions which provide the most likely future, and this report deals mainly with the projections for the MCC. However, a series of alternative future conditions were also identified to evaluate impacts on agriculture. These alternative projections were: (1) historical trend, called the Central Case; (2) OBERS E (least cost with low demand); (3) OBERS E with water constraint; (4)Baseline E Prime; (5) high exports; (6) land and water conservation; (7) environmental enhancement; and (9) energy development. Two of these, (4) and (7) in addition to the MCC, will be addressed in this report.

Objectives

The objectives of this report are: (1) to present estimates of average annual soil losses from water caused sheet and rill erosion for 1975, and projections for 1985 and 2000; and (2) to describe related conservation treatment needed. Both of these broad objectives are related to amounts and quality of available cropland, crop yields, susceptibility of cropland to erosion, and land use adjustments. The information is provided at the Water Resource Region (WRR) and Aggregated Subarea (ASA) levels. The WRR's are shown in Figure 1 and ASA's in Figure 2.

Report Elements

The report is divided into several elements:

1. Methodology used in computing the 1975 cropland sheet and rill erosion losses from water in average annual tons per acre.

2. Methodology used in arriving at the 1985 and 2000 projections.

3. Discussion covering the existing and projected future erosion situation throughout the U.S.

4. Effects of not meeting the 1985 and 2000 Modified Central Case projections.

5. Inputs required to meet the 1985 and 2000 projections.

6. An evaluation of the 1985 and 2000 projections.

Cropland Involved in Study

The magnitude of this study is reflected by the immense acreages of cropland that are involved. The U.S. Department of Agriculture (USDA) reports, prepared for the WRC 1975 National Water Assessment, show that in 2000, 360 million (M) acres of the 425 M acres of available cropland are likely to be harvested for crop production.

Sheet and Rill Erosion Process

To better understand erosion and the problems it causes, a discussion of the erosion process follows. This discussion will be concerned only with erosion caused by water in the form of sheet and rill erosion.

The potential for erosion by water exists whenever there is runoff. The potential is generally greatest on cropland where (1) adequate vegetative cover is lacking, (2) water runoff retarding practices are not used, or (3) physical soil conditions prevent the rapid infiltration of water into the soil.

The removal of soil by flowing water follows two general patterns. The first of these is sheet erosion, the uniform detachment and removal of surface soil. It occurs where soil is exposed to the direct impact of rainfall or improper application of irrigation water, particularly if the surface has been pulverized by cultivation. A second pattern of soil removal is the channeling caused by runoff water. Depending upon the severity of the process, this channeling process is called either rill or gully erosion. Rills and gullies are distinguished by the size of channels left following erosion. Rills are small and can be removed by normal soil cultivation; gullies are too large for removal by normal cultivation. Sheet and rill erosion are the types of greatest occurrence and consequence on cropland.

Soil losses, as calculated in this report, relate to the average annual tons per acre removed from "place" and does not represent the amount reaching streams or other bodies of water. Some soil particles settle out on flatter terrain in or close to the originating field or may be diverted or stopped by grass or other obstructions. In short, many of these losses do not result in sediment in downstream water.

The following cropland conditions that set the stage for high runoff and sediment yield potential are:

1. Long slopes that are farmed without terraces or runoff diversions.

2. Rows up and down moderate or steep slopes.

3. Little or no crop residues on the surface after new crop seeding or harvest.

4. Intensively farmed land adjacent to streams without intervening strips of vegetation or other barriers.

5. Upslope areas from which runoff flows across cropland.

6. Poor stands or poor quality of vegetation.

7. Irrigated slopes without adequate safeguards.

Cropland erosion control requires, among other things, adequate technology, an understanding of the erosion process, competent design of the proper control system, skillful handling of farm machinery, and a thorough knowledge of farming.

METHODOLOGY - 1975 SITUATION

The study areas used for this report are the Water Resource Region (WRR), Aggregated Subarea (ASA), and Major Land Resource Area (MLRA). This report is confined to the 48 contiguous states. The contiguous states were delineated into 18 WRR's and 99 ASA's. The WRR's are based on major river basins and the ASA's on hydrologic units within WRR's. Each ASA is realigned to follow county boundaries. This geographical distribution is shown in Figures 1 and 2.

Another delineation of land is by MLRA compiled by the Soil Conservation Service (SCS). There are 156 MLRA's in the 48 contiguous states. The lands within an MLRA have similar characteristics relative to agriculture with emphasis on combinations and/or intensities of problems in soil and water conservation. The MLRA's are grouped and adjusted to county boundaries for compilation of certain statistical data. The MLRA separations with county line adjustments are shown in Figure 3.

The methodology used to compute soil losses by sheet and rill erosion on cropland during 1975 required a number of data sources, assumptions, and procedures.

Data Sources

1. The Conservation Needs Inventory (CNI) of 1967.
2. The Soil Conservation Service (SCS) "99" report for 1975.
3. Erosion coefficients computed from data provided by SCS field personnel.

Conservation Needs Inventory -

The USDA, with major input from SCS, made a conservation needs inventory on agricultural land in 1958 to learn more about the characteristics and conservation needs of the land. In 1967, the inventory was updated and expanded. For this study, the 1967 data were partially updated with results of the potential cropland study made in 1975. This adjustment provided the cropland base data for this study. The CNI lists aggregated county acreages of dry and irrigated cropland used for row crops, close-grown crops, summer-fallow, rotation hay and pasture, temporary idle cropland, and land use for fruits and vegetables.

The CNI acreages with their component land capability subclasses (LCC) also reflect the four most significant limitations that prevent cropland from unrestricted use. The four limitations are erosion (e); shallow, droughty, stony, or other limiting soil conditions (s); drainage problems (w); and climatic conditions that adversely affect crop

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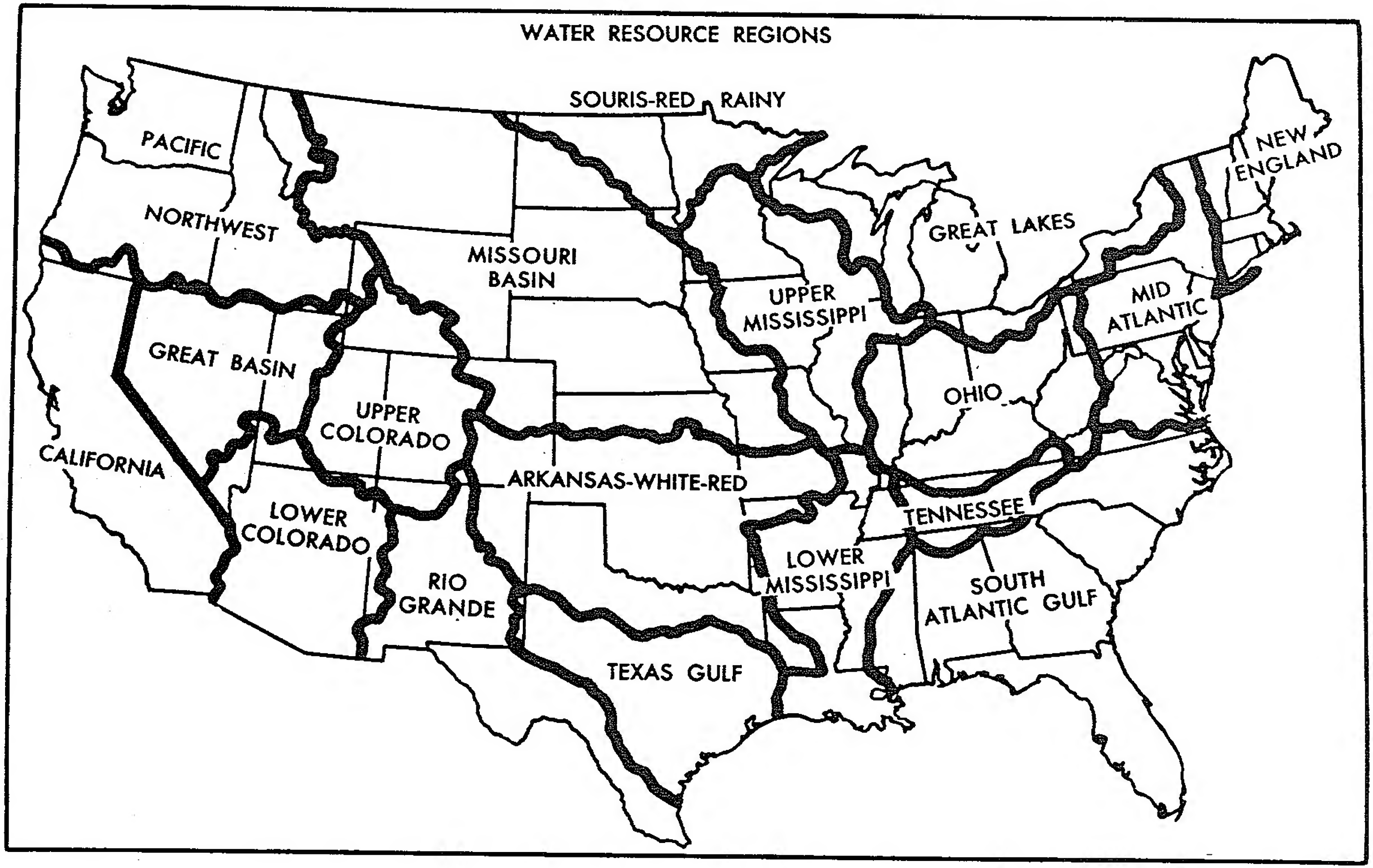

WATER RESOURCE REGIONS
SOURIS-RED
RAINY
PACIFIC
NORTHWEST
MISSOURI BASIN
UPPER MISSISSIPPI
GREAT LAKES
NEW ENGLAND
MID ATLANTIC
GREAT BASIN
UPPER COLORADO
OHIO
CALIFORNIA
ARKANSAS-WHITE-RED
TENNESSEE
LOWER COLORADO
RIO GRANDE
LOWER MISSISSIPPI
SOUTH ATLANTIC GULF
TEXAS GULF

FIGURE 1

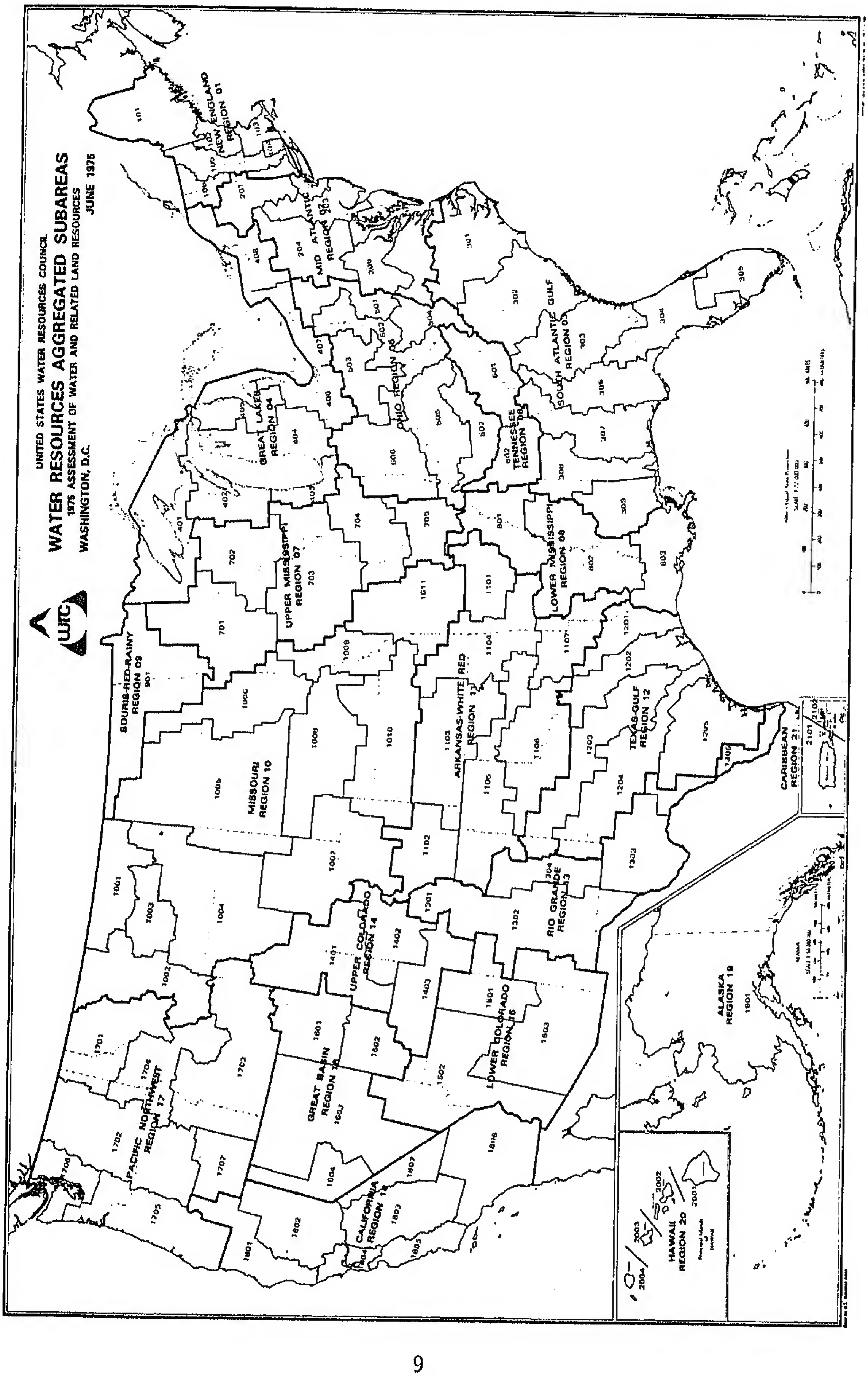

UNITED STATES WATER RESOURCES COUNCIL
WATER RESOURCES AGGREGATED SUBAREAS
1975 ASSESSMENT OF WATER AND RELATED LAND RESOURCES
WASHINGTON, D.C.
JUNE 1975
NEW ENGLAND REGION 01
MID ATLANTIC REGION 02
SOUTH ATLANTIC GULF REGION 03
GREAT LAKES REGION 04
OHIO REGION 05
TENNESSEE REGION 06
UPPER MISSISSIPPI REGION 07
LOWER MISSISSIPPI REGION 08
SOURIS-RED-RAINY REGION 09
MISSOURI REGION 10
ARKANSAS-WHITE-RED REGION 11
TEXAS-GULF REGION 12
RIO GRANDE REGION 13
UPPER COLORADO REGION 14
LOWER COLORADO REGION 15
GREAT BASIN REGION 16
PACIFIC NORTHWEST REGION 17
CALIFORNIA REGION 18
ALASKA REGION 19
HAWAII REGION 20
CARIBBEAN REGION 21

FIGURE 2

Major Land Resource Areas of the United States
Adjusted to County Boundaries for Compilations
of Statistical Data

FIGURE 3

FIGURE 3 (Cont.)

LEGEND

1 Northern Pacific Coast Range and Valleys
2 Willamette and Puget Sound Valleys
3 Olympic and Cascade Mountains (Western Slope)
4 California Coastal Redwood Belt
5 Siskiyou - Trinity Area
6 Cascade Mountains (Eastern Slope)
7 Columbia Basin
8 Columbia Plateau
9 Palouse and Nez Perce Prairies
10 Upper Snake River Lava Plains and Hills
11 Snake River Plains
12 Lost River Valleys and Mountains
13 Eastern Idaho Plateaus
14 Central California Valleys
15 Central California Coast Range
16 California Delta
17 Sacramento and San Joaquin Valleys
18 Sierra Nevada Foothills
19 Southern California Coastal Plain
20 Southern California Mountains
21 Klamath and Shasta Valleys and Basins
22 Sierra Nevada Range
23 Malheur High Plateau
24 Humboldt Area
25 Owyhee High Plateau
26 Carson Basin and Mountains
27 Fallon - Lovelock Area
28 Great Salt Lake Area
29 Southern Nevada Basin and Range
30 Sonoran Basin and Range
31 Imperial Valley
32 Northern Intermountain Desertic Basins
33 Semiarid Rocky Mountains
34 Central Desertic Basins, Mountains, and Plateaus
35 Colorado and Green Rivers Plateaus
36 New Mexico and Arizona Plateaus and Mesas
37 San Juan River Valley Mesas and Plateaus
38 Black, Hualpai, and Cerbat Mountains
39 Arizona and New Mexico Mountains
40 Central Arizona Basin and Range
41 Southeastern Arizona Basin and Range
42 Southern Desertic Basins, Plains, and Mountains
43 Northern Rocky Mountains
44 Northern Rocky Mountain Valleys
45 Alpine Meadows and Rockland
46 Northern Rocky Mountain Foothills
47 Wasatch and Uinta Mountains
48 Southern Rocky Mountains
49 Southern Rocky Mountain Foothills
50 San Luis Valley
51 High Intermountain Valleys
52 Brown Glaciated Plain
53 Dark Brown Glaciated Plain
54 Rolling Soft Shale Plain
55 Black Glaciated Plains
56 Red River Valley of the North
57 Western Minnesota Forest - Prairie Transition
58 Northern Rolling High Plains
59 Northern Smooth High Plains
60 Pierre Shale Plains and Badlands
61 Black Hills Foot Slopes
62 Black Hills
63 Rolling Pierre Shale Plains
64 Mixed Sandy and Silty Tableland
65 Nebraska Sand Hills
66 Dakota - Nebraska Eroded Tableland
67 Central High Plains
68 Irrigated Upper Platte River Valley
69 Upper Arkansas Valley Rolling Plains
70 Pecos - Canadian Plains and Valleys
71 Central Nebraska Loess Hills
72 Central High Tableland
73 Rolling Plains and Breaks
74 Central Kansas Sandstone Hills
75 Central Loess Plains
76 Bluestem Hills
77 Southern High Plains
78 Central Rolling Red Plains
79 Great Bend Sand Plains
80 Central Rolling Red Prairies
81 Edwards Plateau
82 Texas Central Basin
83 Rio Grande Plain
84 Cross Timbers
85 Grand Prairie
86 Texas Blackland Prairie
87 Texas Claypan Area
88 Northern Minnesota Swamps and Lakes
89 Minnesota Rockland Hills
90 Central Wisconsin and Minnesota Thin Loess and Till
91 Wisconsin and Minnesota Sandy Outwash
92 Superior Lake Plain
93 Northern Michigan and Wisconsin Stony, Sandy, and Rocky Plains and Hills
94 Northern Michigan Sandy Drift
95 Southeastern Wisconsin Drift Plain
96 Western Michigan Fruit Belt
97 Southwestern Michigan Fruit and Truck Belt
98 Southern Michigan Drift Plain
99 Erie - Huron Lake Plain
100 Erie Fruit and Truck Area
101 Ontario - Mohawk Plain
102 Loess, Till, and Sandy Prairies
103 Central Iowa and Minnesota Till Prairies
104 Eastern Iowa and Minnesota Till Prairies
105 Northern Mississippi Valley Loess Hills
106 Nebraska and Kansas Loess - Drift Hills
107 Iowa and Missouri Deep Loess Hills
108 Illinois and Iowa Deep Loess and Drift
109 Iowa and Missouri Heavy Till Plain
110 Northern Illinois and Indiana Heavy Till Plain
111 Indiana and Ohio Till Plain
112 Cherokee Prairies
113 Central Claypan Areas
114 Southern Illinois and Indiana Thin Loess and Till Plain
115 Central Mississippi Valley Wooded Slopes
116 Ozark Highland
117 Boston Mountains
118 Arkansas Valley and Ridges
119 Ouachita Mountains
120 Kentucky and Indiana Sandstone and Shale Hills and Valleys
121 Kentucky Bluegrass
122 Highland Rim and Pennyroyal
123 Nashville Basin
124 Western Allegheny Plateau
125 Cumberland Plateau and Mountains
126 Central Allegheny Plateau
127 Eastern Allegheny Plateau and Mountains
128 Southern Appalachian Ridges and Valleys
129 Sand Mountain
130 Blue Ridge
131 Southern Mississippi Valley Alluvium
132 Eastern Arkansas Prairies
133 Southern Coastal Plain
134 Southern Mississippi Valley Silty Uplands
135 Alabama and Mississippi Blackland Prairies
136 Southern Piedmont
137 Carolina and Georgia Sand Hills
138 North - Central Florida Ridge
139 Eastern Ohio Till Plain
140 Glaciated Allegheny Plateau and Catskill Mountains
141 Tughill Plateau
142 St. Lawrence - Champlain Plain
143 Northeastern Mountains
144 New England and Eastern New York Upland
145 Connecticut Valley
146 Aroostook Area
147 Northern Appalachian Ridges and Valleys
148 Northern Piedmont
149 Northern Coastal Plain
150 Gulf Coast Prairies
151 Gulf Coast Marsh
152 Gulf Coast Flatwoods
153 Atlantic Coast Flatwoods
154 South - Central Florida Ridge
155 Southern Florida Flatwoods
156 Florida Everglades and Associated Areas

production (c). The county acreages and their limitations permit the estimation of the productive capacity and erosion hazards of these lands. The data in the CNI provides a base for predicting soil losses relative to cropping management systems and land treatment.

Conservation Practices in 1975 -

The extent of conservation practices on the land in 1975 was estimated using data from the SCS 99 report, an annual report prepared by SCS field personnel. It contains a listing of the amount of each major soil and water conservation practice on the land at reporting time within each county of the U.S.

Erosion Coefficients (1975) -

Erosion coefficients were computed from basic data provided by SCS state offices for use in the Universal Soil Loss Equation (USLE) for areas east of the Rocky Mountains. In the areas west of the Rocky Mountains, direct estimates of soil losses were provided by SCS personnel.

Universal Soil Loss Equation (USLE)

Estimation of soil losses were made by using data from sources previously mentioned.

Two procedures were used for making the soil loss estimates. For cropland east of the Rocky Mountains, factor indices were used in the USLE. For cropland in the "West," certain factor indices had not been developed when the basic data were generated and field personnel provided direct per acre estimates of annual soil loss.

The USLE is A = RKLSCP where:

A is the estimated soil loss in tons/acre/year.

R is a measure of the erosive forces of rainfall and runnof. It is a measure of frequency and intensity of rainfall in a given area.

K is the soil erodibility factor. It relates inherent properties of soils to soil movement by raindrop impact and runoff.

L and S are topographic factors that represent the combined effects of slope length (L) and steepness of slope (S).

C is the plant cover and cropping management index. It represents the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled, continuous fallow.

P reflects the benefits of supporting conservation practices such as contour farming and contour stripcropping. Because terracing modifies the length and steepness of slope, terraces are reflected in the equation of L and S rather than P.

A "T" value is often associated with the USLE. It defines the maximum annual soil loss per acre in tons that can be sustained without adversely affecting the productivity of the land. As a point of interest, current sustained crop production standards for soil loss tolerances used by the Soil Conservation Service for conservation planning is an average "T" not exceeding 5 tons/acre/year. Lower values are specified for certain soils.

Table 1 illustrates pertinent L, S, K, and T factors by soil and LCC. These data are applicable to the area east of the Rocky Mountains. Information shown in Table 1 applies to MLRA 107. Table 2 furnishes data applicable to a "Western" area, MLRA's 48 and 49 (Colorado). These were selected simply to illustrate the form of the data.

Assumptions

The major set of assumptions for the 1975 estimates concerned the allocation of land treatment across the land base by capability class and subclass and by practice combinations. It was assumed that:

1. The extent of conservation practices on each land capability class and subclass was the same as the proportion of the land in the land capability class and subclass.

2. Terraces, contour stripcropping, and contour farming occurred only on land classes II, III, and IV.

3. When combinations of conservation practices were involved, priorities for determining practice combinations were set up as follows:

    a. Terraces

    b. Contour stripcropping

    c. Contour farming

    d. Minimum tillage

    e. Crop residue use

Using the 1975 land base, the acreages of practices were distributed in direct proportion to acres in each LCC that were assumed to require these practices. Acres of contour farming, for example, reported on the SCS

TABLE 1: Dominant Soil, L, S, K, and T Factors by Capability Subclasses (East of the Rocky Mountains).
Iowa MLRA 107

Class & Subclass	Dominant Soil	L-Dom. Slope Length (ft.)	S-Dom. Slope (%)	K Factor	T Factor
				(Tons per acre per year)	
I	McPaul silt loam, 0 to 2 % slopes	> 1200	1	.37	5
IIe	Marshall silty clay loam, 2 to 5 % slopes	300	3	.32	5
IIs	Wadena loam, mod. deep, 0 to 2 % slopes	650	1	.32	3
IIw	Colo silty clay loam, 0 to 2 % slopes	> 1200	1	.28	5
IIc					
IIIe	Marshall silty clay loam, 5 to 14 % slopes, mod. eroded	225	9	.32	5
IIIs	Corr. fine sandy loam, 0 to 2 % slopes	350	1	.24	4
IIIw	Luton silty clay, 0 to 2 % slopes	NA	0	.28	5
IIIc					
IVe	Ida silt loam, 14 to 20 % slopes, severely eroded	300	16	.32	5
IVs	Sarpy fine sand, 0 to 2 % slopes.	175	1	.24	5
IVw	Napa silty clay, 0 to 2 % slopes	NA	0	.28	5
IVc	-----				
Ve	-----				
Vw	Colo silty clay loam, frequently flooded, 0-2 % slopes	> 1200	1	.28	5
Vs					
Vc					
VIe	Ida silt loam, 20 to 30 % slopes, severely eroded	250	22	.32	5
VIw					
VIs	Sparta loamy fine sand, 9 to 14 % slopes, mod. eroded	250	11	.17	5
VIc					
VIIe	Hamburg silt loam, 30 to 75 % slopes	300	45	.32	5
VIIs	Chute loamy fine sand, 9-14 % slopes, severely eroded	250	11	.17	5
VIIw	Marsh	NA	0	---	---
VIIc	-----				
VIIIe	-----				
VIIIs	Riverwash	NA	0	---	---
VIIIw	Broken allwinal land	NA	0	---	---
VIIIc					

TABLE 2: Dominant Soil, L, S, and T Factors and Estimated Soil Lost to Erosion for Selected Cropping & Pasture & Range Systems Colorado MLRA 48 and 49

Capability Class and Subclass	Dominant Soil	L-Dom. Slope Length (ft)	S-Dom. % Slope (%)	T. Factor *	Soil Losses for Selected Cropping Systems*					
					Pasture and Hayland	Dry Beans	Dryland Wheat	Sugar Beets & Corn	Range-Poor Cond.	Range-Good Cond.
I	Fruita loam, 0-1% (I)	800	1	5	2	--	--	4	NA	NA
IIe	Fruita loam, 1-3% (I)	600	2	5	2	--	--	5	NA	NA
IIs	Billings scl, 0-1% (I)	1200	1	5	2	--	--	4	NA	NA
IIw	NA	---	--	--	--	--	--	--	NA	NA
IIc	NA	---	--	--	--	--	--	--	NA	NA
IIIe	Holdermann sl, 3-5%	500	4	5	NA	10	20	5	5.0	0.25
IIIs	Colonne cl, 0-2% (I)	1000	1	5	2	NA	NA	5	NA	NA
IIIw	Uncompahgre sl, 0-3%	1000	1	5	2	NA	NA	NA	NA	NA
IIIc	Collbran l, 0-3%	500	2	5	NA	5	10	NA	2.0	0.25
IVe	Bostwick sl, 5-10% (I)	300	8	5	5	NA	NA	5	NA	NA
IVs	Christianburg c, 0-2% (I)	1200	1	5	2	NA	NA	5	NA	NA
IVw	Yampa l, 0-1%	1200	1	5	.25	NA	NA	NA	NA	NA
IVc	Cerro cl, 0-3%	500	2	5	NA	NA	10	NA	5.0	0.25
Ve	NA	---	--	--	--	--	--	--	--	--
Vw	Big Blue l, 0-5%	1200	1	5	.25	NA	NA	NA	0.5	.1
Vs	Valmont kcl, 1-5%	1000	3	5	NA	NA	NA	NA	0.5	0.25
Vc	Anvik l, 0-3%	300	2	5	NA	NA	NA	NA	0.5	0.25
VIe	Evanston l, 5-20%	500	10	5	NA	NA	NA	NA	5.0	0.5
VIw	Gas Creek grsl, 0-3%	1000	1	2	NA	NA	NA	NA	0.5	0.1
VIs	Gateview kl, 2-8%	500	4	5	NA	NA	NA	NA	1.0	0.25
VIc	Evanston l, 1-5%	800	3	5	NA	NA	NA	NA	1.0	0.25
VIIe	Perlin grl, 5-45%	1000	20	5	NA	NA	NA	NA	5.0	0.5
VIIs	Carbol vrsl, 15-60%	800	35	1	NA	NA	NA	NA	0.5	0.1
VIIw	Vasquez stsl, 5-20%	300	10	5	NA	NA	NA	NA	0.5	0.1
VIIc	Williams l, 0-5%	1200	3	5	NA	NA	NA	NA	1.0	0.25
VIIIe	Badland	50	30	NA	NA	NA	NA	NA	NA	NA
VIIIs	Rock outcrop	50	50	NA	NA	NA	NA	NA	NA	NA
VIIIw	NA	N.A.	NA	NA	NA	NA	NA	NA	NA	NA
VIIIc	NA	N.A.	NA	NA	NA	NA	NA	NA	NA	NA

*Tons per acre per year

"99" report for 1975, were distributed to acres in appropriate LCC in the following order: (1) land with terraces, (2) land with contour stripcropping, and (3) land with neither. A listing of the allocation of land treatment by acres on cropland by WRR and for the Nation is shown in Table 3.

Procedures Used

1. Coefficients were selected from the basic erosion coefficient data set for representative crop rotations by MLRA.

2. Gross sheet and rill erosion and average annual erosion rates were computed by LCC for each MLRA portion of ASA.

3. Gross sheet and rill erosion was aggregated from MLRA portion of ASA's to the ASA level and weighted average rates of erosion were computed for the ASA.

4. The ASA gross sheet and rill erosion rates were aggregated to WRR's. The same process was used for soil loss computations at the national level.

The three major components of the process are (1) erosion susceptibility of soils by LCC, (2) cropping management systems, and (3) use of the USLE including items (1) and (2).

Erosion Susceptibility of Soils

The susceptibility of a soil to erosion depends upon certain soil properties and characteristics. Soil textures, organic matter content, and structural relationships mostly determine the erodibility of a soil. They strongly influence water infiltration, soil particle detachment and transportation runoff. Soil profile features that reflect internal soil drainage are also important. In areas of high rainfall, poor internal drainage may be associated with high erosion potential. Land capability subclasses are grouped by susceptability to erosion and the cropland acreage in each group within each WRR is shown in Table 4.

Cropping Management Systems

The effects of cropping and management variables cannot be evaluated separately. Numerous interrelationships are involved. Some of the variables are kinds of crops, crop rotations or sequences, crop residue use, surface roughness, plant canopy protection, and periods of plant growth within a season.

Since cropping management systems are best known at the field level, SCS field personnel were asked to furnish this data. The systems were grouped by MLRA and one cropping management system considered to be

TABLE 3: Allocation of Land Treatment by Acres on Cropland - 1975 (1000 ac.)

WATER RESOURCE REGION	NONE	CRU	MT	CF CONV. RR	CF CONV. CRU	CF MT	SC CONV. RR	SC CONV. CRU	SC MT	TERR. CONV. RR	TERR. CONV. CRU	TERR. MT	TOTAL ACRES
1. New England	747	73	39	108	17	17	33	5	3	0	0	0	1042
2. Middle Atlantic	4710	1336	526	645	144	66	871	170	80	7	1	0	8556
3. South Atlantic Gulf	6923	6572	538	843	819	50	108	75	13	1445	1357	84	18827
4. Great Lakes	13935	4075	2340	356	74	36	365	83	45	55	12	9	21385
5. Ohio	13266	6130	3933	884	288	212	605	103	66	231	98	88	25904
6. Tennessee	1629	518	95	180	51	12	16	3	1	163	137	9	2814
7. Upper Mississippi	27461	12973	5856	2319	1366	528	1921	600	183	363	220	83	53873
8. Lower Mississippi	6707	9501	263	364	457	15	14	21	1	138	143	2	17626
9. Souris-Red Rainy	6327	9386	445	14	15	3	398	842	14	0	0	0	17444
10. Missouri	26954	26406	3032	1893	1846	310	5327	5832	316	4147	3925	432	80420
11. Arkansas White-Red	10365	15082	650	765	1299	68	168	432	13	2326	3849	135	35152
12. Texas Gulf	6775	8080	460	817	967	59	50	52	2	1908	2431	107	21708
13. Rio Grande	867	1203	80	10	15	1	0	1	0	10	8	0	2195
14. Upper Colorado	377	303	161	1	1	1	4	4	6	1	2	1	862
15. Lower Colorado	482	545	230	0	0	0	0	0	0	5	4	2	1268
16. Great Basin	784	436	277	65	46	32	19	13	8	4	2	1	1687
17. Columbia North Pacific	6997	5080	1605	570	463	165	76	58	25	12	9	4	15064
18. California South Pacific	5546	2044	1699	20	7	7	12	4	4	1	0	0	9344
19. National	140852	109743	22229	9854	7875	1582	9987	8298	780	10816	12198	957	335171

LEGEND:
CF - Contour Farming
CRU - Crop Residue Use
MT - Minimum Tillage
SC - Contour Stripcropping
TERR - Terraces
CONV - RR - Conventional Tillage with Crop Residue Removed
CONV - CRU - Conventional Tillage with Crop Residue Use

TABLE 4: Susceptibility of Soils to Erosion by Cropland Acres, Water Resource Regions and Land Capability Subclasses--1975 (1000 Acres).

WATER RESOURCE REGION	SLIGHT I;s,w,c of II & III; V	MODERATE IIe; IIIe; s, w,c, of IV,VI	SEVERE IVe	VERY SEVERE VIe, VIIe and VIIIe	TOTAL ACRES
1. New England	461	529	44	4	1038
2. Middle Atlantic	2893	4759	668	226	8546
3. South Atlantic Gulf	9134	9402	635	235	19406
4. Great Lakes	13378	7469	405	125	21377
5. Ohio	15115	9225	1202	367	25909
6. Tennessee	795	1628	254	127	2804
7. Upper Mississippi	27108	24250	1903	618	53879
8. Lower Mississippi	14016	2843	219	101	17179
9. Souris-Red Rainy	7600	9518	237	84	17439
10.Missouri Basin	31118	41399	6322	1528	80367
11.Arkansas-White-Red	16902	14733	3059	456	35150
12.Texas Gulf	9958	10302	1208	232	21700
13.Rio Grande	1776	368	38	6	2188
14.Upper Colorado	155	464	205	30	854
15.Lower Colorado	1197	56	3	4	1260
16.Great Basin	924	630	102	9	1665
17.Pacific Northwest	5555	7778	1484	230	15047
18.California	6936	1840	463	109	9348
National	165021	147193	18451	4491	335156

the most typical was selected for each MLRA. The cropping management system, chosen from lists submitted by field personnel for an MLRA, was used as a measure of the combined effects of interrelated plant cover and management variables.

An example of the kinds of cropping management systems and associated "C" factors developed for each MLRA is shown in Table 5. Since each aggregated subarea is usually composed of parts of several MLRA's, a composite cropping system was developed for those MLRA's within an ASA. For example, in ASA 1010, eight cropping systems were used. In ASA 1013, a single rotation was used since ASA 1013 contains only MLRA 157. An example is shown in Table 6.

TABLE 5: Cropping Management Systems and "C" Factor Index for Iowa MLRA 107

Cropping Management System	Conventional Till		Minimum Tillage	No Till
	Residue Removed	Residue Left		
1. Corn-Corn-Soybeans	.49	.42	.27	.18
2. Continuous Corn	.44	.36	.18	.13
3. Corn-Corn-Corn-Oats (gr. manure)	.32	.29	.20	.17
4. Corn-Corn-Corn-Oats-Hay	.21	.17	.12	.09
5. Corn-Corn-Oats-Hay	.15	.12	.10	.08
6. Corn-Corn-Oats-Hay-Hay	.11	.09	.08	.07
7. Corn-Oats-Hay	.07	.06	---	---
8. Corn-Oats-Hay-Hay	.064	.047	---	---
9. Corn-Oats-Hay-Hay-Hay	.052	.038	---	---
10. Corn-Soybean-Wheat	.41	.36	.24	.17

TABLE 6: Composite Cropping Systems Within ASA's
Percent of Rotation in Various Crops

ASA	MLRA	ROT #	CRN	SORG	NLH	WHY	OATS	SOY	CTN	FAL
1009										
	102	42	50			50				
	103	42	50			50				
	106	11				67				33
	107	198	33			33		34		
	108	116	40		20	20		20		
1010										
	67	20	100							
	72	27				75				25
	73	27				75				25
	74	27				75				25
	75	1				50				50
	76	46	33			67				
	112	46	33			67				
	157	46	33			67				
1011										
	107	198	33			33		34		
	108	116	40		20	20		20		
	109	133			25	25		50		
	112	46	33			67				
	113	116	40		20	20		20		
	115	32		100						
	116	133			25	25		50		
1013										
	157	46	33			67				
1101										
	116	133			25	25		50		
	117	86			67		33			
	118	86			67		33			
	131	146						67	33	

LEGEND:
- MLRA - Major Land Resource Area
- ROT - Crop Rotation Used as Part of the Cropping Management System
- CRN - Corn
- SORG - Sorghum
- NLH - Nonlegume Hay
- WHY - Wheat
- OATS - Oats
- SOY - Soybeans
- CTN - Cotton
- FALL - Summer Fallow

EXISTING EROSION SITUATION THROUGHOUT THE U.S. (1975)

There were about 335 million acres of cropland harvested in the 48 contiguous states of the U.S. in 1975. Approximately 170 million acres of this cropland is inherently susceptible to sheet and rill erosion, ranging from moderate to very severe. Continued soil losses on this cropland can cause serious declines in crop production.

The 1975 study reveals an estimated current soil loss on cropland of nearly 3 billion tons averaging almost 9 tons per acre per year. This represents a 25 percent reduction from an estimated potential soil loss of 4 billion tons that would have occurred if no conservation measures were applied to cropland. Specific average annual soil losses for 1975 are shown in Table 7 by ASA and Region. Average annual soil losses are also shown on Figure 4 in the form of an isogram "contour" map which is based on the calculated loss in each MLRA. This gave more soil loss data points and the soil loss averages relate to an area with similar potential erosion conditions.

Excessive erosion on the Nation's croplands would seriously affect the future productive capacity of U.S. agriculture. When soil loss levels for sustained crop production are used as a base, current soil losses on cropland need to be reduced 60 percent. Additional soil and water conservation measures are needed if long term productive capacity is to be maintained. However, a goal of zero erosion on cropland is unrealistic.

Since complete elimination of sheet and rill erosion is not attainable, or even desirable, standards for sustained crop production (SCP standards) have been established to express a maximum soil loss tolerance. This level ranges from 1 to 5 tons per acre per year depending upon the soil. The maximum annual national soil loss for sustained crop production on cropland is about 1.5 billion tons with the current estimated soil loss being approximately 2.8 billion tons.

Potential soil losses without conservation treatment, existing soil losses, and the necessary reduction in soil losses to meet SCP standards are shown in Table 8. Soil losses in most of the WRR within the eastern two-thirds of the U.S. are in excess of tolerable limits. This part of the U.S. produces a large percentage of the crops grown in the U.S. The amount of cropland soil loss is dependent on rate of erosion and acreage of crops grown. Figure 5 shows relative soil losses from cropland from total area.

Average soil losses from sheet and rill erosion are much lower in the western WRR's. In most cases, these losses are substantially below the 5 tons/acre/year. The lower rates in the West are partially caused by lower average annual rainfall, less runoff and much lower rainfall

Figure 4. -- Sheet and rill erosion from water on cropland, 48 states, in 1975

TABLE 7

Cropland Sheet and Rill Erosion by Water

Water Resource Region	ASA	Estimated Average Tons Per Acre Per Year 1/ 1975 MCC	1985 MCC	2000 2/ E'	MCC	EVT
1 New England	101	5.9	0.1		3.9	
	102	7.2	7.3		1.5	
	103	8.5	5.7		1.7	
	104	6.8	11.4		2.8	
	105	5.5	2.3		0.8	
	106	7.3	0.9		0.6	
	Region	6.5	2.4	2.7	1.0	1.9
2 Middle Atlantic	201	11.8	3.7		2.0	
	202	7.0	7.9		4.3	
	203	15.5	6.5		4.1	
	204	10.0	2.9		2.3	
	205	15.0	7.0		4.9	
	206	19.9	9.8		3.1	
	Region	13.8	5.8	6.0	3.4	1.8
3 South Atlantic	301	19.8	6.3		5.6	
	302	17.2	9.2		7.2	
	303	14.9	3.8		6.3	
	304	13.4	7.0		4.9	
	305	6.4	5.0		0.0	
	306	16.1	2.9		5.0	
	307	22.0	5.1		4.9	
	308	20.1	6.0		5.6	
	309	35.0	13.5		2.6	
	Region	18.3	6.9	10.9	5.8	2.5
4 Great Lakes	401	5.0	0.3		0.5	
	402	4.2	4.1		0.8	
	403	5.1	1.6		0.9	
	404	6.2	1.1		2.0	
	405	3.3	0.8		1.3	
	406	3.7	2.1		2.1	
	407	7.5	0.8		1.7	
	408	7.7	1.1		1.7	
	Region	5.0	1.6	2.2	1.6	1.5
5 Ohio	501	7.0	3.3		2.2	
	502	10.0	2.2		3.3	
	503	6.8	2.5		2.7	
	504	11.0	5.4		2.7	
	505	11.0	3.8		1.5	
	506	7.7	4.2		3.3	
	507	12.0	4.8		4.4	
	Region	8.5	3.6	4.2	3.4	2.1
6 Tennessee	601	10.0	3.1		2.4	
	602	25.0	5.4		4.1	
	Region	19.0	5.1	3.7	3.9	2.2
7 Upper Mississippi	701	8.0	4.8		2.6	
	702	8.3	5.7		1.5	
	703	8.7	4.9		3.8	
	704	10.3	5.2		4.5	
	705	17.9	5.9		6.1	
	Region	9.6	5.1	7.6	3.7	2.5
8 Lower Mississippi	801	28.6	13.0		5.1	
	802	19.3	11.8		6.5	
	803	12.0	14.9		6.9	
	Region	22.6	12.6	14.9	5.7	3.1
9 Souris-Red Rainy	901	2.3	1.1		1.1	
	Region	2.3	1.1	2.0	1.1	1.0

1/ Sheet and rill erosion from water. Does not include wind erosion.
2/ The figures in these columns refer to E' E prime base; MCC modified central case; and EVT environmental enhancement.

TABLE 7 (Cont.) - 2 -

Water Resource Region	ASA	Estimated Average Tons Per Acre Per Year 1/ 1975 MCC	1985 MCC	2000 2/ E'	2000 2/ MCC	2000 2/ EVT
10 Missouri Basin	1001	1.5	0.2		0.1	
	1002	1.3	0.4		0.4	
	1003	1.7	0.6		0.6	
	1004	2.0	0.6		0.8	
	1005	2.7	0.6		0.8	
	1006	5.4	1.4		3.0	
	1007	5.9	1.5		1.8	
	1008	9.4	7.0		4.1	
	1009	15.7	3.0		13.1	
	1010	5.7	3.8		2.3	
	1011	19.3	6.7		5.1	
	Region	7.2	2.7	4.5	3.4	1.6
11 Arkansas-White-Red	1101	21.2	4.3		4.0	
	1102	5.9	1.3		0.8	
	1103	4.4	1.7		1.9	
	1104	9.3	5.7		3.5	
	1105	4.5	3.6		1.6	
	1106	5.6	1.9		1.1	
	1107	11.7	12.2		4.8	
	Region	6.0	2.7	3.4	2.0	1.7
12 Texas Gulf	1201	15.1	13.2		7.4	
	1202	12.3	16.7		5.5	
	1203	6.3	3.0		2.7	
	1204	5.6	1.3		1.7	
	1205	7.3	6.6		4.5	
	Region	7.3	4.9	5.6	3.0	1.9
13 Rio Grande	1301	0.8	0.6		0.6	
	1302	0.9	1.6		1.0	
	1303	0.4	4.2		3.8	
	1304	0.3	3.0		2.5	
	1305	3.9	5.1		4.2	
	Region	2.3	3.2	3.0	2.7	2.3
14 Upper Colorado	1401	3.1	2.3		2.9	
	1402	1.7	3.2		2.9	
	1403	1.0	1.6		1.7	
	Region	1.9	2.4	1.8	2.5	1.8
15 Lower Colorado	1501	1.5	1.1		1.2	
	1502	1.5	0.3		0.3	
	1503	1.9	0.8		0.6	
	Region	1.8	0.7	0.6	0.6	0.4
16 Great Basin	1601	2.7	3.6		1.9	
	1602	1.3	2.7		2.0	
	1603	2.4	1.1		1.1	
	1604	2.7	1.4		1.8	
	Region	2.4	2.7	2.5	1.7	1.4
17 Pacific Northwest	1701	3.4	3.2		2.7	
	1702	1.3	1.7		1.9	
	1703	2.8	2.8		1.0	
	1704	5.0	13.7		13.3	
	1705	2.6	2.0		1.7	
	1706	0.6	0.9		1.0	
	1707	2.7	1.6		1.6	
	Region	2.4	4.3	4.3	3.8	1.8
18 California	1801	0.9	1.0		1.0	
	1802	0.4	0.8		0.8	
	1803	0.4	0.8		0.8	
	1804	0.8	0.9		0.8	
	1805	1.2	0.7		0.6	
	1806	0.8	0.9		1.0	
	1807	0.5	0.8		0.0	
	Region	0.6	0.8	0.8	0.8	0.8
National		8.6	4.1	5.7	3.2	1.9

1/ Sheet and rill erosion from water. Does not include wind erosion.
2/ The figures in these columns refer to E' E prime base; MCC modified central case; and EVT environmental enhancement.

TABLE 8: Existing Estimated Erosion Situation by Water Resource Region (1975)

Water Resource Regions	Soil Losses (SL) in Tons				
	Potential SL w/o Conservation Treatments (1000)	Existing SL w/ Present Farming Systems (1000)	Existing SL Average Annual Tons/Acre (Unit)	Maximum Annual SL Based on SCP Standards[1] (1000)	Reduction in SL Needed to Meet SCP Standards[2] (1000)
1. New England	7.915	6.799	6.5	5.21	1.589
2. Middle Atlantic	156.000	120.000	17.2	42.78	77.220
3. South Atlantic Gulf	496.028	344.740	18.3	94.13	250.610
4. Great Lakes	113.863	106.804	5.0	106.804	-------
5. Ohio	293.000	222.000	13.1	129.515	92.485
6. Tennessee	69.000	57.000	32.4	14.065	42.935
7. Upper Mississippi	604.179	515.365	9.6	269.365	246.000
8. Lower Mississippi	492.099	387.774	22.6	85.880	301.894
9. Souris-Red Rainy	50.920	39.412	2.3	39.412	-------
10. Missouri Basin	908.092	576.639	7.2	402.105	174.534
11. Arkansas White-Red	331.755	211.328	6.0	175.760	35.568
12. Texas Gulf	210.642	157.771	7.3	108.510	49.261
13. Rio Grande	8.134	5.019	2.3	5.019	-------
14. Upper Colorado	1.963	1.614	1.9	1.614	-------
15. Lower Colorado	2.278	2.260	1.8	2.260	-------
16. Great Basin	4.877	4.013	2.4	4.013	-------
17. Pacific Northwest	42.506	36.428	2.4	36.428	-------
18. California	5.887	5.281	0.6	5.281	-------
19. National	3799.138	2800.247	8.9	1528.151	1272.096

[1]SCP refers to "sustained crop production standards."

[2]SCP on cropland is based on a maximum of 5 tons/acre/year.

Aggregated Subarea for the 1975 Assessment

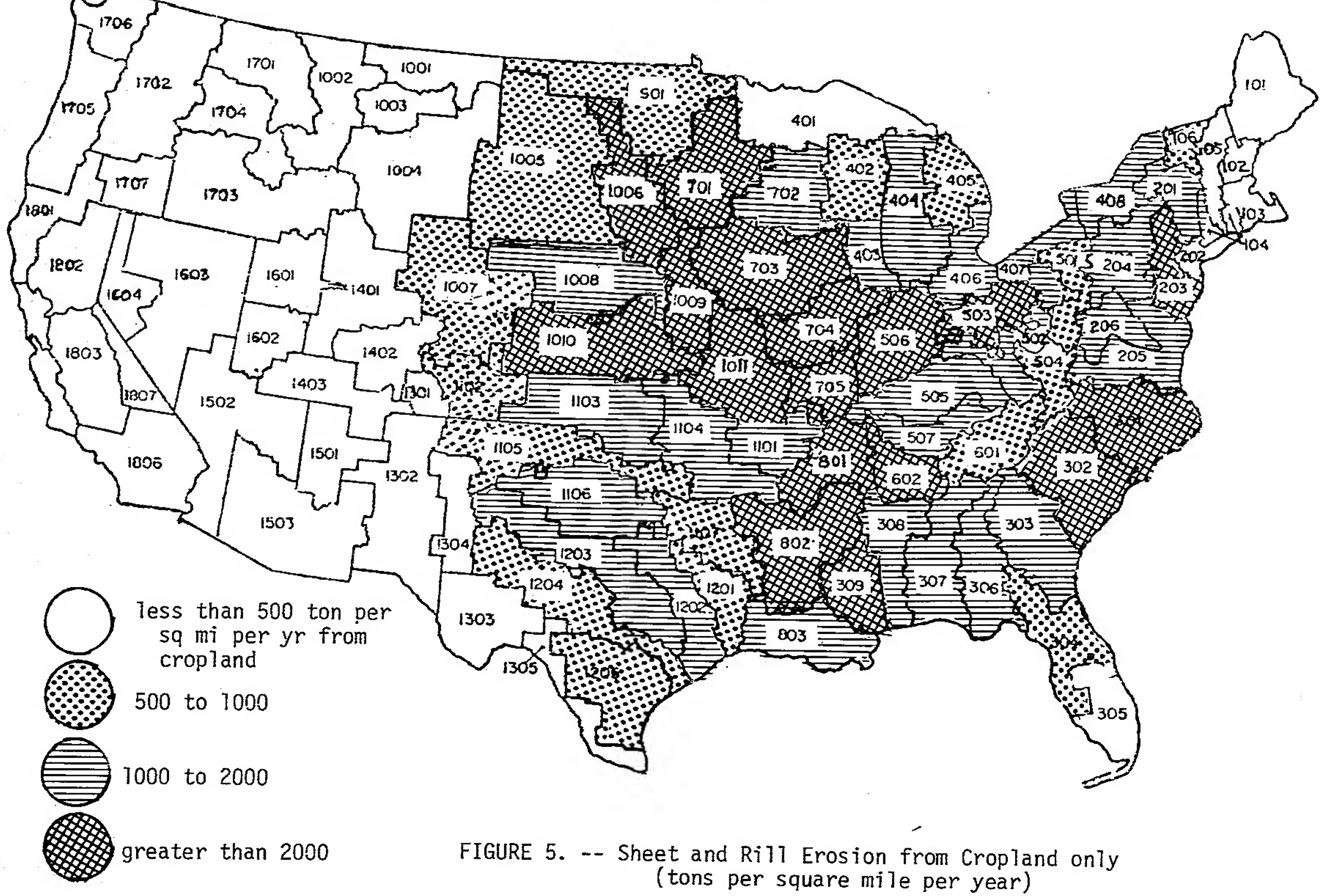


FIGURE 5. -- Sheet and Rill Erosion from Cropland only
(tons per square mile per year)

intensities. Severe thunderstorms usually accompanied by high intensity rains are common to most of the western WRR's. However, they generally occur when plant growth or surface plant residues are sufficient to dissipate the impact of raindrops. Furthermore, these storms are usually local in nature and no one large area is subject to excessive frequent storm occurrences. Therefore, soil losses, when averaged over a large area, are not large.

In certain parts of the Pacific Northwest and Great Basin, much of the erosion that occurs is caused by runoff from snowmelt. Portions of these WRR's and others in the Great Plains are subject to serious wind erosion. Though sheet and rill erosion are somewhat lower in these regions than in the eastern two-thirds of the U.S., other forms of erosion that occur add to the total erosion problem. The effects of these kinds of erosion, though damaging to crop production, are beyond the scope of this particular report.

It is possible for a portion of a WRR to be subject to soil losses considerably above SCP standards though the average soil loss for the WRR may be close to the SCP standard. An example of such a condition occurs in the Iowa and Missouri Deep Loess Hills MLRA which is part of ASA's 1009 and 1011 in the lower portion of the Missouri Basin. Annual soil losses on some of these lands are often double the average for the region. These variations influence the intensities of land treatment needed within the boundaries of the MLRA.

METHODOLOGY USED FOR THE 1985 AND 2000 CROPLAND SHEET AND RILL EROSION PROJECTIONS

A linear programming model, developed by Iowa State University, was used for making the 1985 and 2000 projections. The model provided estimates of land use, water use, commodity production, value of production, agricultural income, employment, land and water conservation, and soil erosion by ASA for the 1975 National Water Assessment. This report, however, is concerned only with soil loss projections, and with the implications, interactions, and constraints pertinent to sheet and rill erosion for 1985 and 2000. Constraints include availability of dry and irrigated cropland by LCC, water, fertilizers, adjustment limits on certain crops and general demands for final products.

Data sources, assumptions, and procedures used for estimating soil losses in 1985 and in 2000 were the same as for 1975 except in a couple of instances. Actually, many of the basic data sources were the same as those used in estimating 1975 soil losses, with some updating. Soil loss limits and regional cropland adjustment constraints for the 1985 and 2000 time periods were the major exceptions. The geographical breakdown by water resource regions, aggregated subareas, and major land resource areas are the same as the 1975 study (Figures 1, 2, and 3).

Data Sources for 1985 and 2000 Projections

1. The land base was obtained by updating the 1967 CNI cropland acres to 1975 to account for irrigation development, urban development, and conversion of some IIw and IIIw lands from other uses to cropland that occurred between 1967 and 1974. These adjustments were made by the ARAS Technical Committee and is the land base used for the 1975 National Water Assessment.

2. Erosion coefficients were the same as those used for the 1975 soil loss estimates.

Modified Central Case Analysis

Assumptions -

1. Cropland acreages in any ASA could fluctuate within the model according to a least-cost criteria as follows:

    a. For 1985 - Acres of individual crops within an ASA were not less than 70 percent nor more than 200 percent of the acreages reported in the 1969 Census of Agriculture.

b. For 2000 - Acreage of individual crops within an ASA was not to be less than 40 percent nor more than 600 percent of the acreage in the 1969 Census of Agriculture.

These assumptions constrained the shifting of crops between ASA's but did not constrain the shifting of crops from one LCC to another within an ASA for more efficient production. The lack of a constraint on shifts within an ASA may be a weakness in the 1985 and 2000 projections.

2. The erosion limit for 1985 was set at 10 times the "T" value not to exceed 40 tons per acre. The erosion limit for 2000 was two times the "T" value. The latter assumption was relaxed to 10 times the "T" value or no more than 40 tons per acre in the Palouse-Nez Perce ASA in the Pacific Northwest WRR and the Deep Loess ASA in the Upper Mississippi WRR.

3. The demand for agricultural output as reflected in the OBERS E' projections would be met.

Procedures -

1. A linear programming model was used that would produce the OBERS E' demand level at a minimum cost and still meet the constraints shown in the above assumptions. The aggregation by ASA, WRR, and the Nation was made and is comparable with the aggregation made of the 1975 data.

2. Soils were grouped according to their susceptibility to erosion (Table 4).

3. Cropping management systems were selected from data submitted by SCS field personnel. No one system was selected for the 1985 and 2000 studies as was done for 1975. Specifically, cropping management systems incorporated rotations of one to four crops covering from one to eight years, with a given conservation treatment, and a given tillage practice. The crop rotations defined in each MLRA were selected within the model from 330 unique rotations. The rotations in each MLRA were determined within the model to meet the OBERS E' level demands. The cropping management system is completed by adding conservation practices such as terraces and strip-cropping; and applicable tillage methods.

4. Estimated soil losses by WRR and ASA were computed.

Alternative Future Case Analysis

Nine future cases were evaluated to provide "what if" answers to alternative policy questions. Two of these cases are compared to the MCC and discussed

in this report, i.e., Baseline E-Prime and Environmental Enhancement. The data base and procedures were the same as the MCC; only certain assumptions to measure impacts of alternative policies were changed.

Baseline E-Prime (E'Base) Assumptions

1. A conversion of pasture and forest on wet soils to cropland would continue to a maximum of 90 percent of the available acreage, providing the conversion could take place with individual landowner action. This assumption was also a part of the MCC.

2. The erosion limit was set at 10 times the "T" value not to exceed 40 tons per acre for both 1985 and 2000.

3. The demand level of the MCC was unchanged and would be met.

Environmental Enhancement (Envt)

1. No land use conversion of wet soils would occur.

2. The erosion limit was set at the "T" value.

3. The demand level of the MCC was unchanged and would be met.

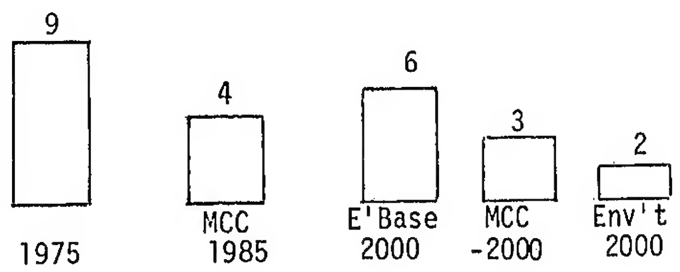
4. Fish and wildlife instream flow needs preempted irrigation water use from surface water supplies.

PROJECTED FUTURE EROSION SITUATION

The Modified Central Case projection shows total national average annual soil losses decreasing from 9 tons per acre in 1975 to 4 tons per acre in 1985, to 3 tons per acre in 2000. Averages for water resource regions and aggregated subareas generally show the same trend. National averages for three alternative futures are shown in Figure 6. Regional averages and a national average for the OBERS E Prime and Environmental alternative projections are shown in Table 8 for comparison. Specific data for each unit of area are shown for the MCC in Table 7.

FIGURE 6

NATIONAL AVERAGE RATES OF EROSION



Where the trend is not downward from 1975 to 2000 within an ASA, there is generally an explanation. For example, in ASA 1006 for the MCC, the erosion rate goes down for 1985 and back up for 2000. The reason is probably the change in constraints placed on the model. In 1985, the model could not increase the acreage of a particular crop by more than 200 percent. In 2000, it could increase by 600 percent. The erosion constraint was the same since this was an area exempted from the 2 T limit in 2000. Since this is a highly productive area, the model could have increased the percentage of cropland on the more erodible soils in this ASA for year 2000.

Significant changes in farming operations are required to achieve each of the three projections. This is covered in a later section.

INPUTS REQUIRED TO MEET 1985 AND 2000 PROJECTIONS

General

Two of the most essential natural resources of this Nation are water and cropland. Their conservation and maintenance are essential if adequate production of agricultural products without degradation of the environment is to be achieved. Public interest, action, and accomplishments are needed if any program concerning cropland resources is to be successful. These programs require input by cropland owners and operators, governmental agencies, and common interest groups in the private sector. Common interest groups include environmentalists, food processors, and those with related responsibilities in transportation, marketing, machinery, and finances. There must be active concern for environmental quality and long term economic efficiency.

Land Management and Conservation Treatment

Major inputs to achieve the future erosion projections of the 1975 National Water Assessment on cropland are proper land management and the establishment of necessary conservation treatments. These activities must be sustained as part of normal and daily cropland operations. They modify sheet and rill erosion by increasing rates of water infiltration and by decreasing runoff rates and volume. Management and treatment include the effective use of vegetative residues as ground cover. Plant cover, efficiently used, is one of the most important conservation treatments available for use on cropland. Additional measures to complement plant cover are runoff interceptors such as stripcropping, terraces, diversions, and contour farming. These measures may be grouped into: (1) practices primarily directed to the control of runoff; and (2) management of fertilizers, animal wastes and pesticides on cropland. Interrelationships exist among these groups. The use of conservation tillage practices to control erosion may result in the use of larger amounts of chemicals to control crop pests. In such cases, the net effect of conservation tillage on the quality of surface and underground water should be considered.

The extent and intensity of management measures and land treatment required to move from the 1975 condition to the year 2000 condition for the three projections are shown in Table 9. This is further illustrated in Figure 7. The MCC change is summarized as follows - national totals:

1. Reduce 141 million (M) cropland acres with "no conservation treatment" by 80 percent.

2. Reduce "crop residue use" as a single conservation practice from 109 M acres to 34 M acres, a decrease of about 70 percent. This conservation practice becomes increasingly beneficial when

Table 9 -- Land treatment in 1975 and in three assumed cases for 2000, in thousand acres

WATER RESOURCE REGION	YEAR and ALT.	CROP-LAND 1/	Tillage Practice and Residue Management											
			Straight Row			Contour			Strip Crop			Terraces		
			Residue: Remove	Residue: Left	Min. Till.	Residue: Remove	Residue: Left	Min. Till.	Residue: Remove	Residue: Left	Min. Till.	Residue: Remove	Residue: Left	Min. Till.
			(thousand acres)											
1. New England	1975	1042	747	73	39	108	17	17	33	5	3	0	0	0
	2000 MCC	359	55	5	0	117	68	0	114	0	0	0	0	0
	2000 E'Base	320	49	0	0	139	46	0	86	0	0	0	0	0
	2000 Envt	750	37	8	0	585	10	0	110	0	0	0	0	0
2. Middle Atlantic	1975	8556	4710	1336	526	645	144	66	871	170	80	7	1	0
	2000 MCC	7848	187	856	159	195	1381	680	0	1567	562	96	386	1779
	2000 E'Base	7848	189	2224	230	90	327	1002	104	1212	1028	0	0	1442
	2000 Envt	7783	15	47	494	256	1352	1454	107	481	639	213	1715	1010
		Gulf												
3. South Atlantic Gulf	1975	18827	6923	6572	538	843	819	50	108	75	13	1445	1357	84
	2000 MCC	18217	0	2979	2616	1203	2173	1688	947	2348	3038	0	500	725
	2000 E'Base	20476	1772	6540	2142	256	1881	2129	1417	1095	2721	0	0	523
	2000 Envt	17319	32	526	3477	125	746	4333	0	4	135	3194	3312	1435
4. Great Lakes	1975	21385	13935	4075	2340	356	74	36	365	83	43	55	12	9
	2000 MCC	20792	990	581	4451	735	1105	11199	146	4	1467	0	0	114
	2000 E'Base	20937	1032	803	5061	357	1474	9967	0	0	2130	64	0	49
	2000 Envt	20035	422	189	2292	696	1379	12262	114	207	2228	0	0	246
5. Ohio	1975	25904	13266	6130	3933	884	288	212	605	103	66	231	98	88
	2000 MCC	27917	1272	533	3539	110	949	12208	213	3735	5171	187	0	0
	2000 E'Base	27014	830	633	3585	15	384	12584	0	2052	6912	0	0	19
	2000 Envt	27275	495	59	2666	110	370	13102	437	463	6856	100	1793	824
6. Tennessee	1975	2814	1629	518	95	180	51	12	16	3	1	163	137	9
	2000 MCC	2498	176	527	168	0	396	0	7	0	801	0	423	0
	2000 E'Base	2350	28	1106	116	0	396	0	29	147	253	0	275	0
	2000 Envt	2311	77	62	461	0	396	0	0	0	79	34	1202	0

1/ 1975 Cropland is estimated acres harvested in the actual year 1975. 2000 cropland is acreages, including fallow (11.5 million nationally), for only the twelve crops endogenous to the LP model. Acreages of exogenous crops (24.8 million) such as specialty crops, vegetables, fruits and nuts and of nonrotational hay (26.7 million) are omitted.

Table 9 -- Land treatment in 1975 and in three assumed cases for 2000, in thousand acres - Continued

WATER RESOURCE REGION	YEAR and ALT.	CROP-LAND 1/	Tillage Practice and Residue Management: Straight Row: Residue Remove	Straight Row: Residue Left	Straight Row: Min. Till.	Contour: Residue Remove	Contour: Residue Left	Contour: Min. Till.	Strip Crop: Residue Remove	Strip Crop: Residue Left	Strip Crop: Min. Till.	Terraces: Residue Remove	Terraces: Residue Left	Terraces: Min. Till.
		(thousand acres)												
7. Upper Mississippi	1975	53873	27461	12973	5856	2319	1366	528	1921	600	183	363	220	83
	2000 MCC	59081	1034	3303	9871	1882	3657	12270	211	2900	15557	238	0	8158
	2000 E'Base	58724	1762	13555	7924	2966	0	16309	691	1384	14133	0	0	0
	2000 Envt	57499	272	662	7901	3437	0	21470	0	4457	12755	0	8	6537
8. Lower Mississippi	1975	17176	6707	9051	263	364	457	15	14	21	1	138	143	2
	2000 MCC	15635	67	3495	1103	0	7644	548	0	1653	423	583	119	0
	2000 E'Base	18937	1236	5032	0	703	6360	2936	0	2101	0	510	59	0
	2000 Envt	10875	0	2	2595	0	3627	1869	0	212	483	559	1528	0
9. Souris-Red Rainy	1975	17444	6327	9386	445	14	15	3	398	842	14		0	0
	2000 MCC	17562	127	2463	0	0	7607	0	0	0	0	0	7365	0
	2000 E'Base	17563	127	9039	0	0	7607	0	0	0	0	0	790	0
	2000 Envt	18097	127	467	0	0	8225	0	0	1785	0	0	7493	0
10. Missouri	1975	80420	26954	26406	3032	1893	1846	310	5327	5832	316	4147	3925	432
	2000 MCC	77640	5080	8801	4487	4755	20740	2317	0	5817	7433	835	14132	3243
	2000 E'Base	69277	8025	11128	5217	1763	16536	2147	0	3644	1408	3611	13697	2101
	2000 Envt	81612	3823	6401	3030	2993	21842	4036	1857	5112	1408	6021	18574	6515
11. Arkansas White-Red	1975	35152	10365	15082	650	765	1299	68	168	432	13	2326	3849	135
	2000 MCC	35930	2498	4438	1948	343	8302	966	63	135	0	2061	14162	1014
	2000 E'Base	34424	2520	7828	74	413	7670	953	0	0	0	2013	12471	482
	2000 Envt	37500	2213	4744	686	2450	5810	1780	0	155	333	3506	14809	1014
12. Texas Gulf	1975	21708	6775	8080	460	817	967	59	50	52	2	1908	2431	107
	2000 MCC	15733	2290	4574	0	0	1922	0	0	0	0	372	6575	0
	2000 E'Base	15615	2582	5099	0	0	1149	0	0	0	0	1731	5054	0
	2000 Envt	20068	4288	1525	87	1118	2030	952	0	534	0	2099	7435	0
13. Rio Grande	1975	2195	867	1203	80	10	15	1	0	1	0	10	8	0
	2000 MCC	1506	669	706	0	0	92	0	0	0	0	0	39	0
	2000 E'Base	1557	641	916	0	0	0	0	0	0	0	0	0	0
	2000 Envt	1710	745	830	0	0	96	0	0	0	0	0	39	0

1/ 1975 Cropland is estimated acres harvested in the actual year 1975. 2000 cropland is acreages, including fallow (11.5 million nationally), for only the twelve crops endogenous to the LP model. Acreages of exogenous crops (24.8 million) such as specialty crops, vegetables, fruits and nuts and of nonrotational hay (26.7 million) are omitted.

Table 9 -- Land treatment in 1975 and in three assumed cases for 2000, in thousand acres - Continued

WATER RESOURCE REGION	YEAR and ALT.	CROP-LAND 1/	Tillage Practice and Residue Management (thousand acres)											
			Straight Row			Contour			Strip Crop			Terraces		
			Residue		Min.	Residue		Min.	Residue		Min.	Residue		Min.
			Remove	Left	Till.	Remove	Left	Till.	Remove	Left	Till.	Remove	Left	Till.
14. Upper Colorado	1975	862	377	303	161	1	1	1	4	4	6	1	2	1
	2000 MCC	1043	1039	4	0	0	0	0	0	0	0	0	0	0
	2000 E'Base	1037	1033	4	0	0	0	0	0	0	0	0	0	0
	2000 Envt	727	606	4	0	0	0	0	0	0	0	117	0	0
15. Lower Colorado	1975	1268	482	545	230	0	0	0	0	0	0	5	4	2
	2000 MCC	1037	919	118	0	0	0	0	0	0	0	0	0	0
	2000 E'Base	1113	1047	66	0	0	0	0	0	0	0	0	0	0
	2000 Envt	1134	986	148	0	0	0	0	0	0	0	0	0	0
16. Great Basin	1975	1687	784	436	277	65	46	32	19	13	8	4	2	1
	2000 MCC	1589	1405	0	0	0	0	0	177	0	0	7	0	0
	2000 E'Base	1607	1566	0	0	0	0	0	0	0	0	41	0	0
	2000 Envt	1604	1233	0	0	104	0	0	177	0	0	90	0	0
17. Columbia North Pacific	1975	15064	6997	5080	1605	570	463	165	76	58	25	12	9	4
	2000 MCC	11459	7138	22	0	907	0	0	2332	0	0	1060	0	0
	2000 E'Base	11159	7369	428	0	831	0	0	2356	0	0	175	0	0
	2000 Envt	10708	5586	22	0	631	0	0	3367	0	0	1102	0	0
18. California So. Pacific	1975	9344	5546	2044	1699	20	7	7	12	4	4	1	0	0
	2000 MCC	4324	3933	237	0	0	0	0	154	0	0	0	0	0
	2000 E'Base	4878	4562	237	0	0	0	0	79	0	0	0	0	0
	2000 Envt	4561	4267	212	0	0	0	0	82	0	0	0	0	0
Contiguous United States	1975	334719	140850	109292	22230	9853	7871	1582	9988	8300	780	10816	12198	959
	2000 MCC	320221	28886	33648	28346	10251	56041	41880	4369	18162	34456	5442	43705	15035
	2000 E'Base	314884	36377	64645	24353	7538	43835	48030	4765	11638	28587	8149	32349	4618
	2000 Envt	321630	25232	15915	23694	12512	45888	61264	6255	13413	24920	17040	57913	17584

1/ 1975 Cropland is estimated acres harvested in the actual year 1975. 2000 cropland is acreages, including fallow (11.5 million nationally), for only the twelve crops endogenous to the LP model. Acreages of exogenous crops (24.8 million) such as specialty crops, vegetables, fruits and nuts and of nonrotational hay (26.7 million) are omitted.

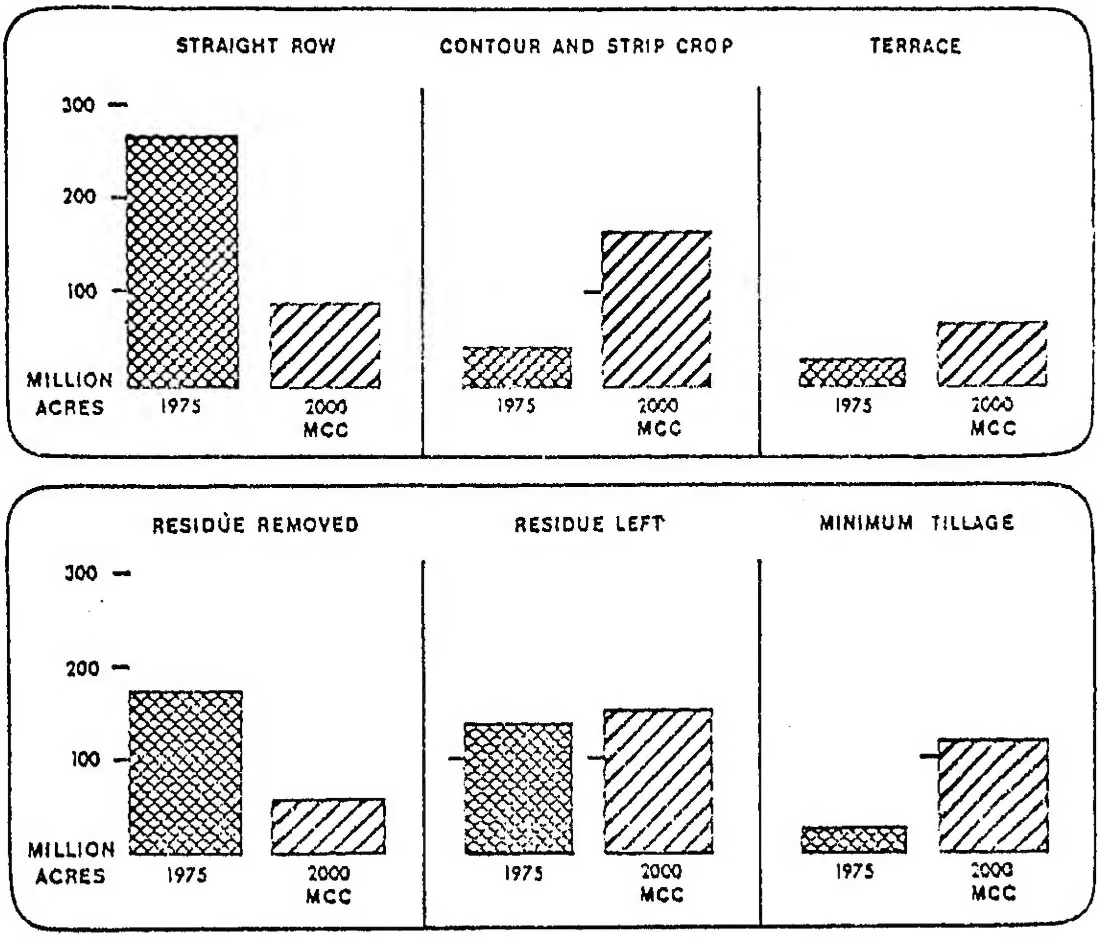


Figure 7.--Changes in land treatment and management measures needed to meet 2000 Modified Central Case erosion reduction on U.S. cropland.

combined with one or more other conservation practices. The decline in this practice as a single practice, simply means that it can be made more effective by using it in combination with other conservation practices.

3. Increase the amount of land with terraces and minimum tillage from slightly less than 1 M acres to 15 M acres.

4. Increase the amount of land with terraces and crop residues left on the surface from 12 M acres to 44 M acres.

5. Increase the amount of land with stripcropping and minimum tillage from about 1 M acres to 35 M acres.

6. Increase the amount of land with stripcropping and crop residues on the surface from 8 M acres to 18 M acres.

7. Increase the amount of land with contour farming and minimum tillage from about 2 M acres to 42 M acres.

8. Increase the amount of land with contour farming and crop residues on the surface from 8 M acres to 56 M acres.

Cropland Adjustments Based on Susceptibility of Soils to Sheet and Rill Erosion

Reducing the amount of cropland used that has severe and very severe erosion problems and replacing it with land less susceptible to erosion is an important way to reduce sheet and rill erosion. Required adjustments in the land capability subclasses used for cropland from 1975 to 2000 to achieve the three projections are shown in Table 10 and summarized for the MCC as follows:

1. Remove 4 M acres (22 percent) in the severe and very severe erosion susceptible categories from production and converting other lands with a lower erosion susceptibility to cropland by the year 2000.

2. Increase by 10 percent (about 14 M acres) the amount of land used for crop production that has a slight susceptibility to erosion. However, this assumes the use of 10 to 11 M acres of wet soils which are presently pasture or forest land.

Agricultural Research and Field Experiment Needs

Research, field experiments, or other appropriate means to carry on current agricultural progress are needed to further fulfill the needs and projections of the future. Resolutions of problems emanating from new or revised methods of cropland farming must be found.

TABLE 10 - SUSCEPTIBILITY OF SOILS TO EROSION

WATER RESOURCE REGION	YEAR & ALT.	CROPLAND Harvested & Fallow Excl. Non-Rot Hayland	Susceptibility of Soils to Sheet and Rill Erosion: SLIGHT I:s,w,c of II & III:V	MODERATE IIe, IIe, s,w,c of IV	SEVERE IVe	VERY SEVERE VI, VII and VIII
		(Thousand Acres)				
1. New England	1975	1038	461	529	44	4
	2000 MCC	640	237	355	27	16
	2000 E'Base	601	247	321	12	16
	2000 Envt	1032	479	521	12	16
2. Middle Atlantic	1975	8546	2893	4759	668	226
	2000 MCC	8701	2990	4712	952	42
	2000 E'Base	8702	3005	4698	952	42
	2000 Envt	8640	2928	4712	952	42
3. South Atlantic	1975	19406	9134	9402	635	235
	2000 MCC	22685	12642	9608	333	98
	2000 E'Base	24944	13980	10052	810	98
	2000 Envt	21788	11092	9952	644	98
4. Great Lakes	1975	21376	13378	7468	405	125
	2000 MCC	22682	14902	9616	587	55
	2000 E'Base	22828	14902	7259	618	45
	2000 Envt	21925	13790	7404	611	109
5. Ohio	1975	25909	15115	9225	1202	367
	2000 MCC	28642	17358	10018	1237	25
	2000 E'Base	27737	17071	9400	1237	25
	2000 Envt	28022	16531	10019	1424	25
6. Tennessee	1975	2804	795	1628	254	127
	2000 MCC	2649	1152	1459	20	14
	2000 E'Base	2501	966	1459	20	14
	2000 Envt	2452	966	1459	20	14
7. Upper Mississippi	1975	53879	27108	24250	1903	618
	2000 MCC	60435	31498	25929	2982	24
	2000 E'Base	60075	31140	25929	2982	24
	2000 Envt	58851	29828	26014	2982	24
8. Lower Mississippi	1975	18179	14016	3843	219	101
	2000 MCC	17669	13511	3570	375	9
	2000 E'Base	20973	17212	3368	379	9
	2000 Envt	12909	9029	3488	379	9
9. Souris-Red Rainy	1975	17439	7600	9518	237	84
	2000 MCC	18737	8802	9894	16	14
	2000 E'Base	10732	8802	9894	16	14
	2000 Envt	19266	8340	10512	395	14

TABLE 10 - SUSCEPTIBILITY OF SOILS TO EROSION

WATER RESOURCE REGION	YEAR & ALT.	CROPLAND Harvested & Fallow Excl. Non-Rot Hayland	Susceptibility of Soils to Sheet and Rill Erosion (Thousand Acres)			
			SLIGHT I:s,w,c of II & III:V	MODERATE IIe, IIe, s,w,c of IV	SEVERE IVe	VERY SEVERE VI, VII and VIII
10. Missouri	1975	80367	31118	41399	6322	1528
	2000 MCC	80241	33941	41381	4015	895
	2000 E'Base	71877	29804	35053	2600	895
	2000 Envt	84211	34993	34993	6201	895
11. Arkansas White-Red	1975	35150	16902	14733	3059	456
	2000 MCC	36893	17893	13785	4634	573
	2000 E'Base	35386	17411	13463	3927	577
	2000 Envt	38463	17644	15692	5156	25
12. Texas-Gulf	1975	21700	9958	10302	1208	232
	2000 MCC	17366	8273	8305	764	15
	2000 E'Base	17178	8150	8124	883	14
	2000 Envt	21632	9538	10868	1196	22
13. Rio Grande	1975	2188	1776	368	38	6
	2000 MCC	1798	1489	287	2	13
	2000 E'Base	1849	1565	256	8	13
	2000 Envt	2003	1534	309	79	73
14. Upper Colorado	1975	854	155	464	205	30
	2000 MCC	1100	275	630	158	32
	2000 E'Base	1093	268	630	158	32
	2000 Envt	784	177	445	154	3
15. Lower Colorado	1975	1260	1197	56	3	4
	2000 MCC	1215	1164	40	5	0
	2000 E'Base	1291	1235	46	5	0
	2000 Envt	1313	1254	48	5	0
16. Great Basin	1975	1656	924	630	102	0
	2000 MCC	1667	1130	494	5	0
	2000 E'Base	1684	1148	524	5	0
	2000 Envt	1683	1147	524	5	0
17. Columbia-North Pacific	1975	15047	5555	7778	1484	230
	2000 MCC	13611	4886	6118	1200	85
	2000 E'Base	13378	4793	7296	1198	85
	2000 Envt	12927	4923	7403	522	73
18. California	1975	9348	6936	1840	463	109
	2000 MCC	8315	6581	1565	262	22
	2000 E'Base	8061	6454	1515	262	22
	2000 Envt	7744	6340	1245	132	20
Contiguous United States	1975	335156	165021	147193	18451	4491
	2000 MCC	345046	179967	146540	17587	1932
	2000 E'Base	338899	178378	142494	16083	1937
	2000 Envt	345645	170516	152760	20886	1473

In many cases, erosion of cropland can be controlled with agronomic methods that improve crop residue management, cropping sequences, seeding methods, soil treatment, tillage methods, and timing of field operations. On many slopes, these agronomic methods must be supported by practices such as terraces, contouring, diversions, and contour stripcropping. The relationship of slope length and steepness are fairly well known on slope lenghts not exceeding 300 feet or slope gradients no steeper than 18 percent. How much these values can be exceeded before relationships change has not been determined. Scientific and field inputs are needed to help answer these questions.

A research effort is needed to develop factors for use in the "Universal Soil Loss Equation" for the Western States. The effect of climate changes from Continental, to Mediterranean, to Desert Types must be determined and fitted into the equation. The problems associated with this scientific procedure in the western croplands are a hindrance to determining the soil losses with an acceptable degree of accuracy and to assessing their contribution to decreasing water quality and production of food and fiber.

New or revised methods of farming may be needed to meet the soil loss projections for the year 2000. Minimum tillage, for example, in the form of "no-till" farming is a relatively new cropland farming method. No-till planting has the potential to reduce man and machine time, soil compaction by implements, and reduces sealing and crusting of the soil surface. Where crop residues are adequate to provide nearly complete surface cover, no-till can be a very effective year-round erosion control method compatible with high yields of certain major crops on suitable kinds of soils. When at least 3 tons per acre of uniformly distributed residues from crops such as corn and grain sorghum are maintained on the soil surface, soil losses can be reduced by 85 percent. No-till planting in chemically killed sod can reduce soil losses by 95 percent or more, compared to conventional farming methods.

However, there are certain problems with this method of farming that need considerable attention for resolution. More herbicides and insecticides are usually required than with plow systems. Nitrogen and phosphorus can be leached from the crop residues left on the surface. However, an increase in runoff pollution by these soluble chemical compounds is usually offset by the much greater reduction in soil losses and runoff. Equipment modifications or new machinery may be required.

No-till is presently not widely used in certain areas, particularly on croplands of the Northeast. In the Pacific Northwest, no-till techniques for winter wheat, as now used in that region, can lead to serious weed infestation, poor seedling development in heavy residues, reduced yields and possible development of plant toxicity. Research is needed to resolve some of these questions and make the system applicable nationwide.

Further studies are needed to determine optimum fertility levels, spacing of crops, rapid early crop growth, early water use by irrigation or by coinciding cropland operations to take advantage of normal seasonal rains, and development of more soil storage capacity for water. All of these factors influence soil losses and runoff. Optimum fertility levels are particularly important for water quality and farm power savings. Knowledge relating to proper depth, time, and quantities of fertilizer applications are essential for soil loss reduction and better water quality.

Double cropping is a relatively new farming system in many areas. The system involves the production of two successive crops on the same field during one year. Double cropping shows promise as a conservation farming system. Growing two crops a year with proper residue management keeps the soil tied down, reducing runoff and water pollution. It can increase crop production and since it allows a reduction in certain farming operations, an opportunity is provided for the saving of fuel and energy. The system is proving especially effective in the Southern and Coastal Plain States. It is also being used with some success in parts of the North Central States. Research is needed for the refinement of this system. There is a need to learn more about crop compatibilities, and the interactions of herbicides, disease control, moisture retention, and economics. More knowledge is required if the system of double cropping is to be expanded to other parts of the U.S. where temperatures and length of growing seasons may be different.

An increase in monoculture is occurring in American agriculture. Monoculture is defined as "the culture of a crop species in an area so that its concentration occupies a dominant portion of the production of that area." It permits intensified production of food and fiber and enables farmers to employ high levels of technology and managerial ability. This helps increase volume of high quality food and fiber. It may reduce production costs. But there are potential problems such as: (1) increased pests and their resistance to pesticides in some cases; (2) increased agricultural pollution; (3) increased vulnerability to crop failure from disease, heavy pest infestation, etc.; (4) increased seasonal labor requirements; (5) economic dependency on a single crop; (6) loss of field edge wildlife habitat; and (7) increased erosion hazard susceptibility.

EFFECTS OF NOT MEETING THE 1985 AND 2000 MCC PROJECTION

In today's agriculture, water quality and soil losses are related. The concern for clean water requires that pollutants to ground and surface waters from agricultural operations be minimized.

Sources of pollutants are usually classed as "point" and "nonpoint." Agriculture generates mostly "nonpoint" sources. These are, by definition, diffuse in nature. Pollutants are discharged into streams and lakes by agricultural runoff, much of which originates on cropland. The "nonpoint" agricultural pollutants of primary concern are (1) sediment, and (2) agricultural chemicals. Should a greater soil loss than that projected for 1985 and 2000 occur, the effects of increased nonpoint pollutants on water quality and of a lowered agricultural productive base for food and fiber would be detrimental.

Effects on Food and Fiber Production

Uncontrolled soil losses over a period of time causes subsoil layers to become increasingly exposed at the surface. At this stage, the effectiveness of fertilizers, high producing varieties, and good crop management may diminish and increased amounts of expensive inputs may have to be used to maintain productive capacity.

There are many factors that have a bearing on the production of crops. Soil productivity, climate, tillage, and cultural management practices, crop varieties, plant genetics, fertilizer and soil amendment levels, expansion of double cropping, monoculture, and erosion are some of the major factors. Any one of these may become limiting in attaining high food and fiber production. Most can be controlled by man. Scientific research and farming experience have pointed out that a deficiency of one factor can be partially offset by substituting additional inputs of one or more of the other factors. The use of higher yielding crop varieties and increased use of fertilizers may mask the adverse effects of soil losses. The process of increasing inputs has in large part been responsible for the tremendous crop yield increases over the past two decades despite continuing losses of soil by erosion.

The importance of soil losses on the effects of reduced crop production may be better explained by comparing yields of soils with top layers intact and similar soils with top layers removed by erosion. For the past three to five decades, field experiments throughout the U.S. have been conducted to study the effects of soil losses on crop production when other limiting factors are held constant. The results of these experiments show that when the upper soil layers are eroded away, the production of various crops on the subsoil layers of the same kind of soil are reduced from 35 percent to 80 percent.

These reductions occur because sublayers of soils are lower in organic matter, have impaired soil structure efficiency, are lower in plant nutrients, and have a reduced soil moisture holding capacity. The reduction in organic matter in the subsoil zones compared to the upper soil layers may be more than 50 percent and the differences in soil nitrogen may be 35 percent or more.

Effects on Water Quality

Agricultural chemicals may be transported to streams, lakes, and ponds in solution in runoff water, suspended in runoff water, or absorbed on soil particles. Soil is the ultimate sink for most widely used agricultural chemicals. Soil particles have chemically active properties that absorb ions of agricultural chemicals. The strong affinity of chemicals to soil particles that are detached and transported in the erosion process make both chemicals and soil particles major contributors to stream degradation and decreasing water quality. An exception to the strong affinity of most agricultural chemicals and soil particles is nitrogen in the form of nitrates that are highly mobile under most soil conditions. Generally, nitrates behave as though they were a tracer of water. This is more evident when soils have a high water content, medium to low cation-exchange capacity, are low in iron and aluminum oxides and have a pH near neutral or lower. Nitrates are generally found in soil solution which means that water runoff from cropland may be influential in contaminating water and reducing its quality.

Finer soil particles from sheet and rill erosion also affect water biology. Suspended particles block sunlight, limit photosynthesis, and inhibit certain aquatic animal life. Eroded soil particles and runoff may contain substantial amounts of phosphorus that usually accelerate eutrophication. Colloidal clay may also absorb phosphorus, heavy metals, and organic compounds that may be in the solution. These extremely fine suspended clay particles carry these pollutants to receiving waters.

Salt, as a pollutant, can be detrimental to both water quality and crop production. In regions where irrigation is required for satisfactory crop production, a concentration of salts accumulate in the surface soil layers through evaporation. In some areas, salt laden eroded materials can cause salt concentrations in stream flows to become high enough that the water may be toxic to plant growth. Also, it requires expensive treatment for municipal and industrial use.

EVALUATION OF THE 1985 AND 2000 PROJECTIONS

In the past four decades, much has been done to alleviate serious erosion problems. But there is still a tremendous job ahead in managing cropland for adequate erosion and runoff control.

The achievement of projected erosion rates relative to sheet and rill erosion, and the improvement of water quality depend on certain factors. Management factors include conservation alternatives, technology, cropland adjustments for both dryland and irrigated cropping purposes, and the use of lands suitable for crops that are presently in other uses. Socioeconomic factors, such as economics, production, goals, social objectives, policy legislation, and the conservation ethic, etc., influence the selection of the management factors. There are many uncertainties that could drastically change the realization of any future projection. Therefore, these projections should be considered valid only for the assumptions on which they are based. Human behavior is uncertain and the response to events remains unpredictable.

Physical Conservation Alternatives and Technological Factors

The physical conservation alternatives and technology concerning soil loss projections for the MCC and their effects on runoff and quality of water are realistic. The technology to achieve the projections is available and will undoubtedly improve or be refined with the passage of time. There are physical and technical alternatives that can be employed for erosion control. Furthermore, conservation measures can be selected and applied for units as small as individual fields and to a level that will not impair the ability of the U.S. to meet demand projections for food and fiber. Individual cropland owners and operators are the key to carrying out soil and water conservation measures on their individual units.

Economic Factors

A most important factor that will influence achievement of the 1985 and 2000 MCC projections are economic considerations. Farming is an economic enterprise and farm operators can be expected to respond to the demands of the marketplace.

The primary motive of many landowners is to maximize short term returns. Costs of farm machinery, materials and cropland values are steadily increasing. There are tremendous financial responsibilities and hazards for today's farmer. Realistically, often the need to pay current expenses and mortgage payments has a higher priority than installing soil and water conservation measures that have a long time payout. Short-range plans may be aimed at relatively quick returns rather than at a high degree of conservation, which most often requires long-range planning and investment.

The "public" is desirous of a least cost full food basket and of foreign exports for balance of international exchange and/or for humanitarian reasons. Additionally, they have desires not expressed in the marketplace. They would like to maintain our Nation's productive resource base, preserve certain agricultural lands deemed necessary for existing ecosystems from being converted to other uses, and prevent excessive amounts of agricultural pollutants from reaching streams, lakes, and reservoirs.

The desires that gain strong public support, are ultimately expressed in law. Farmers and ranchers are responsive to social objectives through a conservation ethic, conservation plans, programs, policies, regulations, and ordinances.

When pollutant materials associated with soil losses originate on cropland, society must expect to share in the cost of abatement. The use of incentives such as insurance and tax rates, grants, cost sharing, and continued governmental technical assistance may be the motivations needed to boost the projections into practical reality.

Adjustments in Land Use Patterns

The extent of adjustments in land use will influence, in part, the degree to which the MCC projections are attained. Though these factors are discussed separately from those on economics, it should be understood that economics are deeply involved in the adjustments of land use and cropping patterns.

Cropland shifts, both local and regional, need to be made by moving crop production from highly erosive lands to less erosive lands. New technology, processing, and transportation of food and fiber may also be factors in changing land-use patterns.

A number of regional shifts in cropland are expected to occur in the MCC projection. The South Atlantic Gulf is projected to increase its harvested acres by 35 percent. Increases are also projected in the Arkansas-White-Red, Souris-Red Rainy, and the Great Lakes. By the year 2000, the Rio Grande is projected to drop 12 percent in harvested acres. Declines in crop acreages harvested are also projected for several of the ASA's.

It is assumed that the regional shifts in cropland use will result in more intensified use of the land remaining in cropland. Therefore, the potential for soil losses are greater on these lands. Adequate conservation treatments will be urgently needed.

Available water supplies will determine the extent of irrigated cropland in several WRR's. Projections indicate that in 2000, the Upper Colorado and Great Basin regions will use all available irrigation water. In the Rio Grande and Lower Colorado regions, most of the irrigation water that is available will be used. In Texas, a further depletion of ground water and a reduction of irrigated acres in the High Plains is expected by 2000.

However, nationally, the number of irrigated acres is only expected to increase 15 percent. These adjustments should not materially add to the problems of soil losses by sheet and rill erosion and water quality.

A shift to cropland from other uses may be from lands in LCC IIw and IIIw. These shifts are not encouraged by most conservationists and environmentalists. However, it should be recognized that the potential exists. The MCC projections for 2000 indicate there may be about 10.5 M acres of wet soils cleared and drained for crops. This conversion, however, would probably not create a serious erosion problem since the natural susceptibility of this kind of land to sheet and rill erosion is normally low.

Shifts in Kinds of Crops

The MCC projections for the future anticipate shifts in certain kinds of crops at local and regional levels. Some factors accounting for these shifts are new or improved crop production techniques; development of new crop varieties that would produce well in new locations; better processing of agricultural products; improved transportation facilities; and increased demand for certain agricultural products.

A shift in crops may result in a need for larger investments in erosion control. A projected rise in silage crops at the expense of oats and barley grains used for livestock feed is an example. Yields of silage and total feed values often exceed those of small grains. Relative profitability of the two types of feed has resulted in an increase in silage production and a decline in oats and barley production. This kind of shift in crops increases the hazards of sheet and rill erosion and runoff. Silage crops such as sorghums and corn, have small amounts of residue remaining on the surface after harvest. These residue amounts provide a low level of erosion control -- almost as low as a bare field. Conservation treatment can compensate for the absence of sufficient residue.

The expansion of soybean production in the South, especially in the Lower Mississippi WRR, is another example of probable crop shifts. Residues left after harvest of soybeans may be ample for surface protection for only short periods of time. Soybean residue deteriorates rapidly. Its brittleness causes it to break down into small pieces. Residue in this condition is easily blown away by wind leaving the surface unprotected.

The citrus industry of Southern California is shifting from relatively level terrain in the coastal area to many steep areas further inland. Citrus groves are being established in many areas on slope gradients of 25 percent or greater. The erosion and runoff hazards are great and much intensive and expensive conservation treatment is essential for erosion control on these lands.

Comparison of Alternative Cases

The projected rates shown in Table 8 should be considered optimistic. Projected rates, treatment, land use adjustments and cropland shifts were derived within the linear programming model. About 10 percent of the crop acreage harvested is exogenous to the model and often on land more susceptible to erosion. Endogenous crop shifts may have been made to land on which it is impractical to change intensity, e.g., small isolated tracts. Some local conditions are not reflected in the soil loss equation and consequently in the derived rate, e.g., snowmelt runoff.

Cropland with some conservation management and/or treatment must increase from 58 to over 87 percent by 1985 for the MCC if erosion is to be reduce as shown in Figure 7 and Table 8. In view of the current rate of applica tion of conservation measures and shortness of the remaining time frame, it seems unlikely that soil losses can be reduced by half by the year 198

Sound conservation techniques and practices are now available to meet erosion control needs for sustained high crop production. It is recogniz there is always a need for refinement of our present knowledge to be considered optimum. The MCC, E'Base, and Environment projections in general are physically attainable.

The MCC and the two alternative projected soil losses are considerably less than what could be expected if historical trends continue. None of the alternative case soil loss projections will become reality without concerted action plans and programs. Objectives must be articulated as policy and then implemented. The E'Base should be a minimum considered. It reflects a least cost of production policy. The production restraints to achieve a soil loss not to exceed 2"T" (MCC) would increase the cost of production 5 percent. A 1"T" and no wet soils drained (Env't) would increase the cost of production an additional 8 percent. Sustained crop productivity of the resource base and a preserved ecological base are advocated at this level. Support for selected policies will dictate the attainment of the soil loss reductions related to that policy.

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